介護施設における認知症高齢者の時間感覚の特性
－時間推移の認識と時間評価－

（Temporal Orientation During the Day in the Elderly with Dementia）

名古屋大学大学院医学系研究科

リハビリテーション療法学専攻

岩元　裕子

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Contents

要旨

【背景】認知症高齢者の主症状の 1 つに時間感覚の障害がある。時間感覚には大別して異なった 2 つの認識要素があり、現在がどのような時間や曜日に相当するかを認識する Time orientation（TO）と、1 分間がどれくらいの長さかというような個々の主観的時間（Time estimation: TE）である。我々の生活は連続する活動で成り立っているため、時間感覚に関する理解を深めることは非常に重要である。本研究では、主研究として 1）施設入所の認知症高齢者における 1 日の TO を調査し、関連研究として 2）健常高齢者と若年者における活動時の感情と TE の関連を調査した。

【方法】1）主研究 : 介護老人保健施設入所高齢者 26 名を対象に、①1 日の TO 調査、② 時間作成課題による TE の測定、を行い解析した。1 日の TO 調査では、施設行事のない水曜日の 9:00 から 18:30 までに 7 回時刻を尋ねる質問を行い、分単位で回答を得た。TE の測定では、被験者が 1 分間経過したと感じた時点でストップウォッチを止める、時間作成課題を行った。回答された時刻と実時間との差の絶対値（Absolute ΔT）を比較し、Mini-Mental State examination（MMSE）および 1 分間の測定値（TE-60）との関連を調べた。2）関連研究 : 健常高齢者 28 名、若年者 31 名を対象にジグソーパズル課題を行い、課題実施時の TE を比較検討した。24 ピースおよび 54 ピースのパズル課題施行後、何分間課題を行っていたと感じるか、口頭にて回答を得た。TE と実時間の比率（Duration-judgment ratio : DJR）と課題難易度、および課題実施時の感情との関連について検討した。

【結果】1）主研究 : 1 日の TO 調査より、午前中で実際の時間より遅い時間に、午後には実際の時間より早い時間と認識されており、特に午前中（10:30）における時間のずれは午後より大きかった。また、MMSE 総得点および TE-60 は 14:00 の Absolute ΔT 以外との関連を認めなかった。2）関連研究 : 高齢群の課題実施時間は若年群と比べ、有意に長かった。いずれの群においても、課題難易度によって DJR に有意差が認められ、特に 24 ピース課題では、高い興味を持って取り組んだ者ほど DJR が小さく、すなわち時間が速く過ぎるように感じていた。

【考察】主研究では、認知症高齢者の TO が午前中により障害されていることを示した。健常者の認識に基づく午前中に行われる活動について対象者には正しく理解されていない場合も考えられるため、時間見当を意識させる内容を午前中に実施することが妥当であると考えられた。関連研究では、TE は年齢、課題難易度および感情に影響されることを示した。多種の感覚や運動刺激に加え、高齢者の TO および TE の特性を考慮し、リハビリテーションを提供する時間帯と内容を見当することが重要であると考えられた。

Abstract

Objective: To clarify the ability to estimate the time in elderly people, I conducted two experiments. In the main experiment, I evaluated the ability to estimate the time of day in the elderly with dementia during the daytime in a care facility, and, in the supplemental experiment, investigated the relationship between time perception during tasks and subjective feelings in young and elderly people. **Main experiment: Methods**: Time orientation was sequentially tested by asking 26 elderly with mild to severe dementia the time of day 7 times a day. The Mini-Mental State examination (MMSE) and a time estimation test for 1 minute were also conducted. **Results**: Time orientation was affected more in the morning than in the afternoon, and meals did not have a significant effect on time orientation. The accuracy of time estimation for 1 minute was correlated with the MMSE score, and with time orientation at 14:00. **Supplemental experiment: Methods**: Simple and complex jigsaw puzzles were given to healthy young and elderly subjects. The subjects were asked to estimate the time they had taken to complete the puzzle tasks after performing them. The ratio of the subjective to absolute duration of time, the duration judgment ratio (DJR), and relationship between the DJR and subjective feelings during tasks were analyzed.

Results: The elderly group required a significantly longer time than the younger group for both tasks. The effect of the task on the DJR was significant, and the value was higher in the 24- than in the 54-piece task in both groups. The DJR was smaller in subjects with "much interest" than in those with "little interest" in the 24-piece task. **Conclusion**: Impaired time orientation was more evident in the morning than in the afternoon. This characteristic should be taken into account when conducting cognitive tests including time orientation for patients with dementia. Interventions facilitating time orientation might be arranged preferentially in the morning for patients with dementia. The results in the supplemental study indicated that time perception was modulated by subjective feelings during the task, as well as by the age and complexity of the task. It may be important to take into account the characteristics of time estimation and orientation in elderly people with and without dementia during intervention.

1. Experiment 1

1.1. Introduction

Recognition of time is an important cognitive function in our daily lives. This relates to most of our cognitive attributes, including perception, experience, memory, and every thought and feeling (Jobst, 2011). Recent studies have suggested that subjective time perception is strongly linked to what occupies the time and how one perceives it, pleasant or stressful (Chaston & Kingstone, 2004; Green, 2008; Larson & von Eye, 2010). Since our life is a sequence of periods occupied with activities, understanding of time recognition is important in the field of occupational therapy (Larson, 2004; Larson & von Eye, 2010, Iwamoto & Hoshiyama, 2011).

There are two concepts of time recognition, time perception and time orientation. Time estimation or time production can be determined as the ability to estimate the temporal duration of time, which requires attention and cognitive control related to the frontal lobe, basal ganglia, and also cerebellum and motor-related cortices (Buhusi & Meck, 2005; Matell & Meck, 2004; Coull, 2004; Macar, Anton, Bonnet, & Vidal, 2004). Time orientation is the ability to identify "when" in a scale of hours, days, months, or years, which seems to relate to the circadian behavioral rhythm (Benton, Vanallen, & Fogel, 1964; Saper, Lu, Chou, & Gooley, 2005) and memory (Varney & Shepherd, 1991; Saper et al., 2005). Although both time perception and orientation are closely related to each other in cognitive function, the clinical use and meaning of these functions differ.

Numerous studies of time estimation have been carried out in the medical and psychological fields. Age-related changes in time perception in healthy subjects (Block, Zakay, & Hancock, 1998; Craik & Hay, 1999; Baudouin, Vanneste, Pouthas, & Isingrini, 2006; Iwamoto & Hoshiyama, 2011) and disruption of time perception in patients with dementia (Carrasco, Guillem, & Redolat, 2000; Rueda & Schmitter-Edgecombe, 2009) have been reported. Most previous studies on time perception were performed under experimental conditions, and time perception over a relatively short duration of up to several minutes under experimental conditions is basically irrelevant to daily functioning (Block et al., 1998; Craik & Hay, 1999; Rueda & Schmitter-Edgecombe, 2009).

On the other hand, another perception of time, time orientation, has been tested as one of the common parameters in routine mental status tests, such as the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975; Berrios, 1983; Tractenberg, Weiner, Aisen, Kaye, & Fuh, 2007). Disorientation of time is rare in healthy elderly (Sweet, Suchy, Leahy, Abramowitz, & Nowinski, 1999), and disorientation of time in MMSE was correlated with the severity of dementia (Ryan, Glass, Bartels, Bergner, & Paolo, 2009). Recent studies reported that disorientation of time is one of the indicators of the early stage of dementia, mild cognitive impairment (O'Keeffe, Mukhtar, & O'Keeffe, 2011; Malek-Ahmadi, Davis, Belden, Jacobson, & Sabbagh, 2012), and, as O'Keeffe et al. (2011) reported, there was a strong relationship between the duration of the hospital stay and disturbance in identifying the date of the month and day of the week in patients with dementia or delirium. There may be no doubt that there is a relationship between time orientation of the year, month, day (O'Keeffe et al., 2011), or even time (Quittre, Olivier, & Salmon, 2005) and memory of social and environmental cues. In identifying the time of the day, we are given extrinsic and intrinsic cues, such as daily activities with various information, sunlight and dawn, and physical fatigue and hunger feelings, etc. If orientation regarding the time of day is related to the amount of environmental cues during a day, the capacity for time orientation might show a characteristic change. However, to my knowledge, there are few studies which have investigated time orientation in association with daily cues in elderly patients with dementia.

In the present study, I investigated time orientation to identify the perceived time of day of elderly with dementia in a care facility. The objective of the present study was to clarify the ability and characteristics of time orientation in elderly with dementia. One hypothesis was that time orientation to identify the time might be disrupted and fluctuate during a day in patients with dementia in a care facility, due to their loss of memory of daily cues. At the same time, I would like to clarify whether or not so-called sundown syndrome is related to the disruption of time orientation. The second hypothesis was that, since meals could be major events in a care facility, time orientation in patients might be preserved at mealtimes. Therefore, I sequentially tested time orientation during one day. I also measured time perception for 1 minute in the patients, since time orientation might be generated by a summation of short periods. Relationships among values of time orientation and time perception and a dementia scale, MMSE, were discussed. This is a pilot study to clarify the characteristics of time orientation during the day in elderly with dementia, which should provide therapists with important information to arrange daily intervention programs for them.

1.2. Method

1.2.1. Participants

Twenty-six elderly participants (6 men and 20 women, mean age: 87.0 ±7.0 (SD) years, range: 67-98) were involved in the present study. All participants were in an elderly care facility in Japan. All met the Diagnostic and Statistical Manual of Mental Disorders (Fourth Edition; DSM-IV) criteria for dementia and scored between 5 and 21 on MMSE assessments, which were conducted in the morning of the day before the study by an occupational therapist. All participants were considered to have senile dementia of the Alzheimer type from the clinical history of dementia, although the diagnosis was not histopathologically confirmed. Patients with other specific types of dementia, if diagnosed, such as diffuse Lewy-body disease, fronto-temporal dementia, dementia with massive stroke, and Parkinsonism with dementia, were excluded. The participants had no difficulty in hearing in their daily lives, and they could orally communicate with the examiner. Subjects with severe cognitive impairment with whom communication was impossible, those considered too sick to be questioned, and those who were unwilling to participate were excluded. Profiles of the participants are summarized in Table 1.

The protocol of the study was explained with a written document to each participant, and one of the family members signed an informed consent form to participate in the study, which was first approved by the Ethical Committee of Nagoya University, School of Health Sciences, prior to commencing the study.

1.2.2. Experiments

Time orientation task

Participants were tested in 7 sessions during a day (Wednesday) regarding their time orientation. All data were collected by the same examiner, by testing one or two participants on each Wednesday. In each session, an examiner tested their time orientation by asking the time of day. Answers were recorded in the participant's own words. Patients who said they could not answer or were unsure about any item were encouraged to provide their best estimate. Making sure the participant could not look at a watch or clock, each interview was performed in each participant's own room, where there was no clock on the wall, and watches or other clocks were covered by cloths so they could not to be seen by the participant. Participants were required to answer what time of day they thought it was. Seven sessions were performed just after every meal and tea time (meal sessions), at 9:00, 12:30, 15:30, and 18:30, and between each meal (interval sessions), at 10:30, 14:00, and 17:00. Since the time for meals and tea was fixed every day in the care facility, the meal and tea times could be cues based on oral intake in the participants. There was no other time-fixed program on Wednesday in the care facility. The time difference (ΔT) and absolute ΔT in minutes between the true time and perceived time of each participant was obtained in each session. For example, when a participant responded that the time was noon at 14:00, the ΔT and absolute ΔT values were −120 and 120 min, respectively. Then, the ΔT and absolute ΔT values underwent further analyses.

Time estimation task

A time estimation task was applied for the second experiment in the morning on another Wednesday 1 or 2 weeks after the time orientation task. The method was similar to the time production method of Block et al. (1998). Subjects sat on a chair or wheelchair in a quiet room, and an examiner told them to close their eyes and start time estimation on hearing a beep sound. Then, participants were asked to stop the timer when they thought 1 minute had elapsed. All the questions and time estimation tasks took place in the morning on another day after the time orientation task in their own rooms. The absolute difference between 60 seconds and the time estimated by each participant, expressed as the time estimation-60 (TE-60) value, was assessed.

1.2.3. Data analysis

The ΔT values were compared by one-way (sessions) repeated measures analysis of variance (ANOVA) followed by Bonferroni-Dunn's correction for multiple comparisons among all sessions. Relationships between the absolute ΔT value and TE-60 or MMSE score were compared using Spearman's rank-correlation coefficient test. A p-value of less than 0.05 was considered significant.

The absolute ΔT was also compared among sessions using ANOVA followed by Bonferroni-Dunn's correction. In addition, absolute ΔT values in three inter-meal sessions after meals (9:00, 12:30, and 18:30, after-meal sequence), and three sessions (10:30, 14:00, and 17:00, inter-meal sequence), were compared using two-way (sequence and three session) analysis of variance with Bonferroni-Dunn's correction for multiple comparisons. A p-value of less than 0.05 was considered significant.

1.3. Results

Temporal orientation task

All participants could answer during the sessions. The main effect of the sessions on the mean ΔT value was significant ($F [6, 150] = 6.93$, $p< 0.0001$, ANOVA) (Figure 1). Multiple comparisons revealed that the ΔT value was larger in the 9:00 session than in the 17:00 and 18:30 sessions, and the 10:30 session showed a larger value than the 15:30, 17:00, and 18:30 sessions. The values in the 14:00 sessions were larger than in the 17:00 session. The correlation curve between ΔT and the time of day (minutes) was: $y = -0.2 x + 181.81$.

There was a main effect of sessions on the absolute ΔT value for all seven sessions ($F [6, 150] = 4.27$, $p = 0.0005$, ANOVA). Multiple comparisons showed that the absolute ΔT value at 10:30 was significantly larger than those at 12:30, 14:00, 15:30, 17:00, and 18:30 ($p < 0.01$) (Figure 2). For comparison between after- and inter-meal sequences, there was no interaction in the absolute ΔT change between the sequences, but there was a main effect of the three sessions ($F [2, 50] = 6.34$, $p< 0.0026$, ANOVA), although there was no difference in the value between the sequences (Figure 3).

Time estimation task

Twenty-four participants could perform the time estimation test for 1 minute, excluding 2 participants, who had difficulty in understanding the task. The mean estimated time was 19.6 ±12.8 seconds (range: 2.5-60.8). Twenty-three participants underestimated the time of one minute, i.e., they stopped the timer before 1 minute. There was a significant negative correlation between the TE-60 and absolute ΔT values in the 14:00 session (ρ=-0.47, z= -2.26, p=0.025), but the values in the other sessions were not correlated. The TE-60 value was positively correlated with the MMSE score (ρ=-0.51, z= -2.43, p=0.013).

MMSE score

The MMSE score was obtained from all participants. The mean score was 14.4 ±4.0 (SD) (range: 8-21). There was no significant correlation between the MMSE score and absolute ΔT value obtained in any session, but a tendency was recognized in the 14:00 session (ρ=-0.36, z= -1.81, p=0.059).

1.4. Discussion

The present results are summarized as: 1) time orientation in patients with dementia was affected by the time of day, more in the morning. They perceived the time as later and earlier than the actual time in the morning and afternoon, respectively, 2) time estimation for 1 minute, which was negatively correlated with the MMSE score, was correlated with time orientation at 14:00, and the MMSE showed no significance but a tendency toward a correlation with absolute ΔT at 14:00, 4) meals did not significantly affect time orientation.

Temporal orientation during the day

A major finding in the present study was that time orientation depended on the time of day the examiner questioned the participants. In the morning, disruption of time orientation was evident at 10:30, and the time perceived by participants shifted to later than the actual time, and, in the late afternoon, it shifted oppositely to earlier than the actual time. The correlation curve for the subjective time of participants crossed the actual time at 15:09, which suggested that the participants gave a relatively correct time at around 15:00, although this did not indicate that the participants correctly oriented themselves to the real time. It was interesting that elderly patients with dementia did not give the time of day randomly, but tended to orient their time around early-mid afternoon. Since the ΔT value linearly decreased during the day, as shown in Figure 1, the value does not simply seem to relate to the sum of cues during a day, such as meals or tea time.

Form the results of the present study, there is a possibility that time orientation might not be randomly disrupted in each patient but stereotyped. The tendency to give a similar time of day in patients with dementia could be a kind of symptom of perseveration (Assal & McNamara, 2007; Pekkala, Albert, Spiro, & Erkinjuntti, 2008). However, I considered another reason for the disruption of time orientation in the patients. Without information regarding time orientation due to memory disturbance, or without a memory of cues in daily living, subjective time orientation in the patients might become vague. They might then judge their subjective time of day as a similar time during a day. Memory loss regarding getting-up, meals, and experiences in a day caused vague time orientation in patients. Results of two-way ANOVA between the after- and inter-meal sequences suggested that meals could not always be a cue to help participants orient to the time of day. In such cases, subjective time may shift to a time without specific cues, which might be early-mid afternoon. With a loss of memory of cues, the patients might conclude, “it is not meal time, nor morning or night; therefore, it should be afternoon now”. This is one speculation, but the present results suggested that the subjective time in patients with dementia was not random but rather consistent during the day.

The analysis of absolute ΔT among sessions revealed that the time deviation from the real time was larger, especially at 10:30, than in later sessions. This analysis suggested that the deviation in time orientation was greater in the morning. In patients with dementia, sundown-agitating behaviors, sundown syndrome, were often observed (Little, Satlin, Sunderland, & Volicer, 1995), and the abnormal behaviors were caused by the biological circadian rhythm (de Jonghe, Korevaar, van Munster, & de Rooij, 2010). However, since time orientation was not disrupted specifically in the late afternoon, the effect of a normal/abnormal circadian rhythm, if there was any, on time orientation might differ from that of sundown syndrome.

Relationship among temporal orientation, estimation, and MMSE

All participants underestimated 1 minute, and the accuracy of estimation was correlated with the MMSE score. These results were also consistent with a previous report regarding time estimation in the elderly with dementia (Craik & Hay, 2009; Carrasco et al., 2000). The result of the time estimation task, TE-60, was correlated with MMSE, and the TE-60 value was correlated with absolute ΔT only at 14:00. Although I did not measure MMSE and TE-60 on every ΔT measurement, the conventional dementia scale and results of the time estimation task did not correlate with absolute ΔT at any other time except 14:00. This feature of time perception is in line with previous results, which indicated no relationship between time orientation and time estimation (Damasceno, 1996).

The MMSE score showed no correlation with the absolute ΔT value. The tendency toward a correlation between the MMSE score and absolute ΔT value at 14:00 suggested that the severity of dementia could be partly evaluated by a question on the time of day. However, at most times of day, the response was not indicative of the severity of dementia. Clinical tests for time orientation in the range of days and months, which are longer periods than hours, were found to be indicative of the severity of dementia (Guerrero-Berroa et al., 2009; O'Keeffe et al., 2011). As O'Keeffe et al. (2011) reported, the clinical significance of time orientation could differ among ranges of time, i.e., years, months, days, and hours.

In previous reports, cognitive functions were also influenced by the time of day (Madhusoodanan et al., 2010; Hasher, Chung, May, & Foong, 2002). We did not measure MMSE in every session in the present study, and so the relationship between the general cognitive function and time orientation still remains unclear, requiring investigation in further studies. However, it is important to take into account that time orientation fluctuates during a period, when we conduct cognitive tests or questionnaires regarding time orientation, during a day, week, or even year.

Possible intervention for disrupted time orientation

There are few studies on intervention specifically for time disorientation. Intervention for time orientation might be conducted partly during reality orientation therapy for patients with dementia (Holden and

Sinebruchow, 1978; Zanetti et al., 2002; Patton, 2006). It may not be practical to intensively apply cognitive training for time orientation, but, since time orientation is one of the basic aspects of cognition of the environment, therapists may pay more attention to enhance time orientation during conventional intervention. For example, therapists gradually presenting information on time during intervention with the aid of clocks may be effective for patients' cognition of time, especially in the morning when their time orientation was disrupted more than at any other time.

Limitations

There are some limitations of the study. One was that I did not collect data from healthy elderly to compare with the data from elderly with dementia. Healthy elderly live based on their own schedules, and so it is not possible to control their activity and experience during a day. For healthy persons, it is practically difficult to spend time without knowing the time of day. A sample size of 26 patients might be too small to apply the present results to a larger population. Multi-center studies would be required to clarify a general characteristic of time orientation in elderly with dementia. Another was that the time estimation task and MMSE were applied only one time for each participant, as mentioned above. Repetition of the same task might have learning effects on the results.

In conclusion, I asked participants the time of day to investigate time orientation in the elderly with dementia. Subjects did not answer randomly, but tended to orient their time around early-mid afternoon. The disruption of time orientation was more evident in the morning than in the afternoon. It may be important to take this into account when we conduct cognitive tests, as time orientation may alter during a day, week, or even year. As seen in time orientation, understanding fluctuations of the brain function in the elderly with dementia during the day would be important for supporting their lives, as well as for devising interventions.

2. Experiment 2

2.1. Introduction

As the adage "time flies" tells us, we feel that time passes quickly when we enjoy ourselves. On the other hand, we feel that it is slow when we are bored. Time perception, which is a subjective feeling of time passing, changes depending on physical and emotional factors regarding the current personal status (Larson, 2004). Recent studies have suggested that subjective time perception is strongly linked to the quality of activity performed (Chaston & Kingstone, 2004; Green, 2008; Larson & von Eye, 2010). For example, when time passes quickly, activities are often viewed as pleasant (Gupta & Cummings, 1986). Thus, time perception is an important factor during occupational therapy, which might promote clients' positive experiences (Larson & von Eye, 2010).

From the results of the previous study, the internal clock and memory system were suggested to be important determinants of time perception (Wiener & Coslett, 2008), and it has been speculated that attention and working memory and attention processes are essential in time perception (Becchio & Bertone, 2006). As Chaston & Kingstone (2004) reported that concentration led to an underestimation of time, the maintenance of attention during a task is an important factor determining subjective time perception. However, most previous studies regarding time perception have been carried out in the field of psychology, and they focused on time perception of a relatively short duration up to 2-3 minutes (Block et al., 1998; Craik & Hay, 1999; Chaston & Kingstone, 2004; Rueda & Schmitter-Edgecombe, 2009), and those studies were carried out under experimental conditions. I considered that time perception for a few minutes during one particular task could not be applied to that during another task, although a long time period may be a sum of short durations. I thought that it is important to understand time perception during an actual activity taking a practical period of time.

Previous studies reported that elderly subjects estimated time to be shorter than young subjects during a task without temporal information (Craik & Hay, 1999), and elderly subjects estimated time to be longer than the actual time when they had nothing to do (Block et al., 1998). Those reports investigated time perception among ages and tasks, but the results were not consistent. In addition, abnormal time perception has been reported in patients with dementia (Wiener & Coslett, 2008; Rueda & Schmitter-Edgecombe, 2009) and spatial neglect (Husain et al., 1997; Basso et al., 1996; Bartolomeo et al., 2005). Although the pathophysiology of spatial neglect has been analyzed in numerous studies (Halligan et al., 1998; Adair & Barrett, 2008), little is known regarding the neuropsychology and pathophysiology of time perception. Since patients with abnormal time perception may be our clients, as well as healthy elderly people, we, as occupational therapists, should have an understanding of time perception in order to provide clients with effective sessions. Contrarily, the time perception of clients may also give us information regarding their physical and mental states, as Larson & von Eye (2010) suggested.

Therefore, in the present study, focusing on healthy people, I investigated time perception in young and elderly people during tasks requiring a relatively long time of ten minutes or so. In addition, since time perception was considered to be linked with subjective feelings and perception during a task (Larson, 2004), I performed an investigation of subjective feeling during a task, e.g., subjective feelings of interest and difficulty during the task. I discussed the psychological mechanisms of time perception during tasks based on the hypothesis of Larson (2004). The objective of this study was to clarify the characteristics of time perception, relating them with subjective feelings during the task, using globally well-known jigsaw puzzle tasks. I consider that the present study provides useful information on time perception in the clinical situation of occupational therapy (OT).

2.2. Method

2.2.1. Participants

Twenty-eight elderly (8 men and 20 women, mean age: 69.9 ±6.2 (SD) years, range: 60-85) and thirty-one young (8 men and 23 women, mean age: 21.9±1.4, range: 18-24) participants were involved in the present study. The elderly subjects had no behavioral or clinical symptoms of dementia or mild cognitive impairment, and their scores in the mini-mental state examination (MMSE, Folstein et al., 1975) were in the normal range over 28 points. The young subjects were university students who obtained a full score in MMSE (30 points). All participants denied having any motor, sensory, or cognitive symptoms that would adversely affect their participation in the present study. They showed no detectable visual, auditory, or speech disturbance on performing jigsaw puzzle tasks, and no speech disturbance on answering questions asked by examiners.

The protocol of this study was explained with written documentation to all participants, and written informed consent to participate, which was first approved by the Ethical Committee of Nagoya University, School of Health Sciences, was obtained from all participants prior to commencing the study.

2.2.2. Experiments

Participants were asked to complete two jigsaw puzzles with different complexities, and a time estimation test was applied during the puzzle tasks. All tasks were performed in a quiet room in the afternoon.

Time estimation tests were performed during the two puzzle tasks. One was a simple task with 24 pieces, and the other was a complex task with

54 pieces. The order of the two puzzle tasks was selected randomly for each participant. Thus, participants were randomly divided into two groups: those who performed the 24- or 54-piece puzzle first (cross-over design). They were specifically instructed to concentrate on completing the puzzle tasks. Examiners told participants to start a puzzle task on hearing a beep sound, and to stop the task 17 minutes and 17 seconds later after hearing another beep sound. The fixed time limit for the tasks, 17 min and 17 sec, was chosen because it is irregular, and so difficult to estimate.

Just after finishing the puzzle tasks, participants were asked to verbally state how long in minutes and seconds they thought they had spent on the task. If a person completed the puzzle task before 17 min and 17 sec, they were asked their perceived duration of time when they finished the task. Therefore, participants performed the first puzzle task, time estimation, and then the second puzzle task. Subjects knew that they would be asked the time after finishing the first puzzle task for the second puzzle task, and so a subject's attention on the time estimation task may have differed between the first and second tasks. Therefore, we arranged the present tasks as a cross-over design.

2.2.3. Subjective feelings during tasks

After the two puzzle and time estimation tasks, subjects were asked to answer a questionnaire regarding interests and feelings during the puzzle tasks. To assess their feelings of interest, they were asked to select one of the following: much interest, some interest, and little interest. For other feelings, they were asked to select, if any, one of four different feelings: engaging, difficult, enjoyable, and interesting.

2.2.4. Data analysis

I measured the time required to complete each puzzle task, and then the ratio of the subjective to absolute duration of time, the duration judgment ratio (DJR) (Block et al., 1998), was calculated for each task. The values of tasks for groups performing the 24- or 54-piece task first were averaged. A DJR of 1.0 indicates that the participants' estimated time was equal to the actual time, whereas a DJR of less than and greater than 1.0 indicates the under- and overestimation of time, respectively. The time required to complete the puzzles and DJR values were compared using two-way (groups and tasks) analysis of variance with Tukey-Kramer's tests for multiple comparisons. For subjective feelings, the DJR values were compared among the four grades of interest and among the four different feelings employing Mann-Whitney tests. A p-value less than 0.05 was considered significant.

2.3. Results

Twenty-six and two elderly subjects completed the 24- and 54-piece jigsaw puzzles, respectively, and all young subjects completed both puzzles. Excluding subjects who did not complete a puzzle, the elderly group took 486.14 ± 209.87 (mean ± SD) and 1,035.32 ± 6.24 sec, and the young group needed 127.29 ± 33.77 and 466.65 ± 115.28 sec for the 24- and 54-piece jigsaw puzzles, respectively (Table 2, Figure 4). The elderly group required a significantly longer time than the younger group ($F [1, 114] = 444.5$, $p < 0.001$, ANOVA). The DJR values are shown in Fig. 5. Both elderly and young subjects estimated that tasks took a longer time than they actually did, i.e., the DJR value was above 1.0. The effect of group on the DJR was not significant in each task ($F [1, 114] = 0.75$, $p = 0.385$). However, the effect of the task on the DJR was significant ($F [1, 114] = 31.75$, $p < 0.001$), and the value was greater in the 24- than in the 54-piece task in both groups ($p < 0.01$, Tukey-Kramer's test).

Subjective feelings during the tasks are presented in Tables 3 and 4. The number of subjects, who felt the task was difficult was higher in the elderly than in the young group in each task (Table 3, $p < 0.05$, Mann-Whitney tests). The number of young subjects who answered that the task was interesting was greater than in the elderly subjects for the 54-piece task ($p < 0.05$).

Among the sub-groups of each grade of interest, the DJR was smaller in the group with "much interest" than in that with "little interest" for the 24-piece task ($p < 0.05$, Mann-Whitney tests), but there was no difference for the 54-piece task. Subjective feelings of "engaging", "difficult", and "enjoyable" had no effect on the DJR.

2.4. Discussion

The present results can be summarized as: 1) subjects estimated that tasks took a longer time than they actually did, 2) subjects estimated a longer time for the 24- than 54-piece task, 3) there was no difference in time estimation between the young and elderly groups, although the feeling of difficulty was significantly different between the groups, and 4) subjects interested in the task estimated a time shorter than those not interested in both the young and elderly groups. The present study clarified behaviors in young and elderly subjects regarding time estimation, which have been theoretically reported (Larson, 2004, 2010).

The DJR value was more than 1.0 in both tasks in both young and elderly groups. This indicated that the subjects felt that the time passed slower than it actually did during the tasks. An early psychological study reported that, when mentally concentrating or in a new job, time was perceived as longer than it actually was (Flaherty, 1987). Although subjective time estimation is variously modified by the mental state, as described later, the time estimated by subjects was protracted fir both tasks. The 24-piece task had a greater effect on protracted time estimation than the 54-piece task in both groups. These results regarding the subjective estimation of time are generally in line with those in previous studies (Zakay et al., 1983; Druyan et al., 1995), although another study reported that task complexity had little effect on time perception (Craik & Hay, 1999).

The effects of aging on time estimation have been investigated in many studies (Carrasco et al., 2001; Coelho et al., 2004). Coelho et al. (2004) reported a change in the estimation and production of time intervals with aging, suggesting an association of aging with a faster "internal clock", which resulted in a longer subjectively estimated time than the absolute time, at least over a short duration of around 10 sec. However, Craik & Hay (1999) reported a contradictory result in experiments using a longer time of up to 120 sec. In the present study, there was no significant effect of aging on time estimation during the task. Since the time estimation task had a relatively long cut-off, 17 min and 17 sec, it might not be possible to compare the results to previous studies (Carrasco et al., 2001; Coelho et al., 2004; Craik & Hay, 1999). The effect of aging on time estimation in the range of minutes to hours is still unclear (Artieda & Paster, 1996), as well as for a short duration (Nichelli, 1993).

One explanation concerning the effect of aging in the present study may be plausible based on Larson's model of time perception (Larson, 2004; Larson & von Eye, 2010) (Fig. 6). Time perception could be explained by the task content, as well as psychological condition. When a task during time estimation was successful, time passed slowly, i.e., a low DJR. On the other hand, when the task was challenging, subjective time passed quickly. When the task was difficult, being a subject's ability, the estimated time again became long. Both young and elderly subjects successfully completed the 24-piece task. Young subjects were challenged by the 54-piece task, and their subjective time estimation was shorter than for the 24-piece task. However, for elderly subjects, the 54-piece task was difficult to perform, as shown in Tables 2 and 3, and the time estimation was long in the range of "beyond ability" (Fig. 6). I considered that it was important to take into account not only the absolute complexity of tasks, but also subjects' feelings during tasks or how they performed in them.

I may have to take into consideration another factor affecting time perception during the 54-piece task. Since the 54-piece task was actually beyond the ability of elderly people, the Figure 3 could partially explain the present results. However, as the majority of elderly subjects could not complete the 54-piece task in 17 min and 17 sec, the goal in the task for elderly subjects was different from those in the other tasks. Factors affecting time perception during the 54-piece task in the elderly group might include disappointing or unsatisfactory feelings, which related to not only the difficulty of the task but also the task's goal or result. Although I ought to ask subjects about time perception during the tasks, time perception could be affected by the goal or result of the task in both young and elderly subjects. Therefore, there might remain a possibility that the location of time perception during the 54-piece task in elderly on the curve in Figure 6 was due to a different factor, i.e., the finished or unfinished outcome of the task.

Another novel result in the present study was that the subjects' feelings of interest in the task affected the time estimation. This result suggested that time perception during a task, or an occupation, could be modified by one's mental attitude and manner, and that involvement with interest in a tasks shortens a subject's time perception. Besides the numerous studies which have investigated time perception and absolute factors, such as aging, task complexity, or interval (Zakay et al., 1983; Druyan et al., 1995; Craik & Hay, 1999; Carrasco et al., 2001; Coelho et al., 2004), relative factors should be important to manage the time perception of clients during occupational therapy, since spending a productive time and the quality of daily activities could be linked to time perception (Larson, 2004; Larson & von Eye, 2010).

Time perception is a kind of ongoing subjective feeling. Therefore, investigation by asking subjects about their feelings after an event may be limited. As shown in the present results, time perception could be quantitatively evaluated, but the subjective value might change based on the outcome of the performance or occupation. To clarify the characteristic of time perception, a comparison of the feelings after compared with those during an ongoing task might be necessary in future studies.

In conclusion, I investigated the characteristics of time perception during the performance of jigsaw puzzle tasks. Subjective feelings modified time perception in both young and elderly subjects, and a part of the results could be explained by a model of time perception in an occupation. Occupational therapists should consider these features. As Larson (2004) pointed out, if the client perceives a daily task as disinteresting, there are shifts in mindfulness during the task or an increase in cognitive and emotional involvement. Conversely, if a task of daily living activity is too challenging, the therapist might redesign the task by reducing the complexity and increasing the client's skill. Through knowing the characteristics of time perception in each client, occupational therapists could employ such knowledge to use the time for interventions effectively, as well as employ it as personal information on the client.

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Table 1

Profile of the participants

No.	Age (years)	Sex	MMSE	TE-60 (sec)
1	78	M	12	2.5
2	85	F	10	13.4
3	79	M	20	31.3
4	90	F	13	17.0
5	91	F	17	38.9
6	88	F	16	30.6
7	92	F	9	xxx
8	89	F	21	17.6
9	95	F	11	7.7
10	91	M	20	9.9
11	78	F	20	60.6
12	91	M	19	18.5
13	84	F	13	27.7
14	67	F	12	6.6
15	82	F	14	12.9
16	80	M	18	32.7
17	90	M	8	19.0
18	96	F	12	21.3
19	98	F	12	5.6
20	92	F	16	20.2
21	84	F	12	9.3
22	89	F	14	9.2
23	93	F	13	16.8
24	84	F	20	19.3
25	94	F	14	22.4
26	82	F	8	xxx
Average (SD)	87.0 (7.2)	M : F: = 6 : 20	14.4 (3.9)	19.6 (12.8)

MMSE: Mini-Mental State Examination, TE-60: absolute difference between 60 sec and the time estimated by each participant, xxx: unable to perform the task.

Table 2

The mean time required for the tasks in the two groups.

	Elderly group (n=28)		Young group (n=31)	
Task	24-piece	54-piece	24-piece	54-piece
Completion (n)	26	2	31	31
Time (sec, mean ± SD)	486.1 ± 209.9	1,035.3 ± 6.2	127.3 ± 33.8	466.7 ± 115.3

Table 3

"Yes" responses regarding subjective feelings during the tasks (n, (%)).

	Elderly group (n = 28)		Young group (n = 31)	
Task	24-piece	54-piece	24-piece	54-piece
Engaging	28（100）	28（100）	25（81）	27（87）
Difficult	5（18）	24（86）	0（0）	6（19）
Enjoyable	23（82）	22（79）	24（77）	28（90）
Interesting	22（79）	21（75）	23（74）	28（70）

Table 4

The mean DJR in sub-groups of each grade of interest in the two groups (mean, (SD)).

	Elderly group (n=28)		Younger group (n=31)	
Task	24-piece	54-piece	24-piece	54-piece
Much interest	1.34 (0.40) (n = 9)	1.08 (0.64) (n = 8)	1.21 (0.28) (n = 4)	1.10 (0.46) (n = 10)
Some interest	1.82 (0.44) (n = 13)	1.13 (0.52) (n = 13)	1.75 (0.84) (n = 19)	1.27 (0.52) (n = 18)
Little interest	2.14 (0.68) (n = 5)	1.09 (0.15) (n = 4)	2.33 (0.62) (n = 8)	0.86 (0.18) (n = 3)

Figure 1

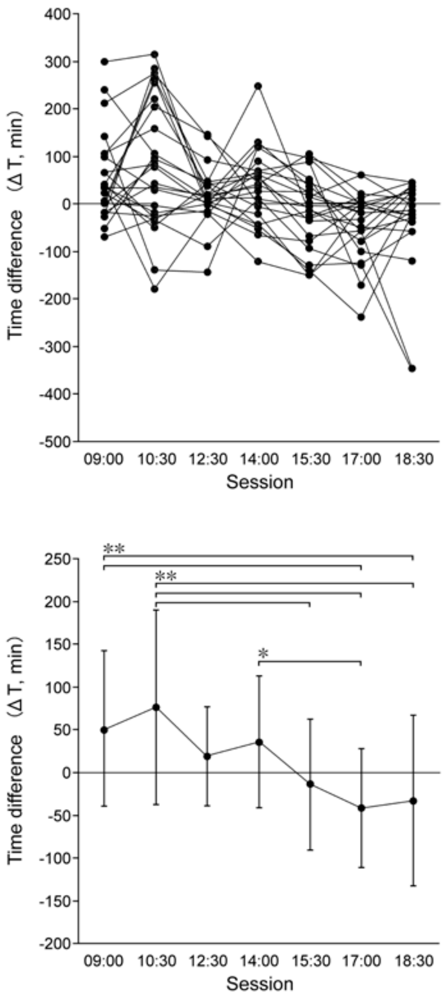

Figure 1. The individual (top) and mean (bottom) values of time differences (ΔT) in all participants. Subjects perceived a later time in the morning and earlier time in the afternoon than the actual time (** $p<0.01$. * $p<0.02$, ANOVA, Bonferroni-Dunn's correction). Zero (0) indicates the actual time on each question. The vertical bars in the bottom graph indicate the standard deviation. Correlation curve is: $y = -0.2x + 181.8$.

Figure 2

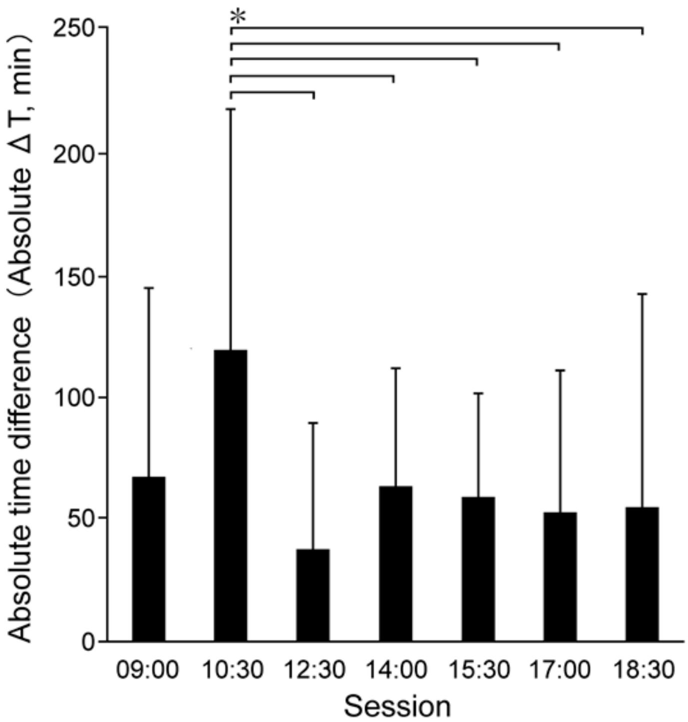

Figure 2. Mean absolute time difference (absolute ΔT) in all sessions. The absolute ΔT value at 10:30 was larger than in later sessions (* $p<0.01$, ANOVA with Bonferroni-Dunn's correction).

Figure 3

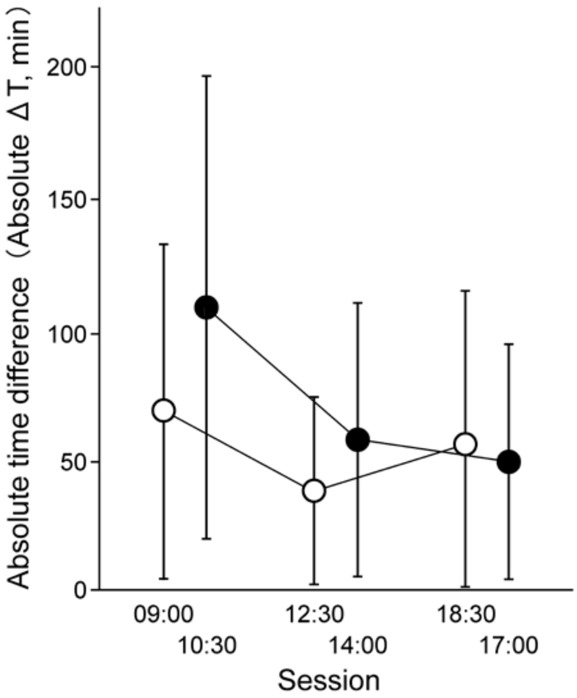

Figure 3. Mean absolute time difference (absolute ΔT) in the after- (open circles) and inter-meal (solid circles) sequences. There was no significant interaction or difference between the two sequences, although the value at 10:30 was significantly larger than in the other sessions, as shown in Figure 2.

Figure 4

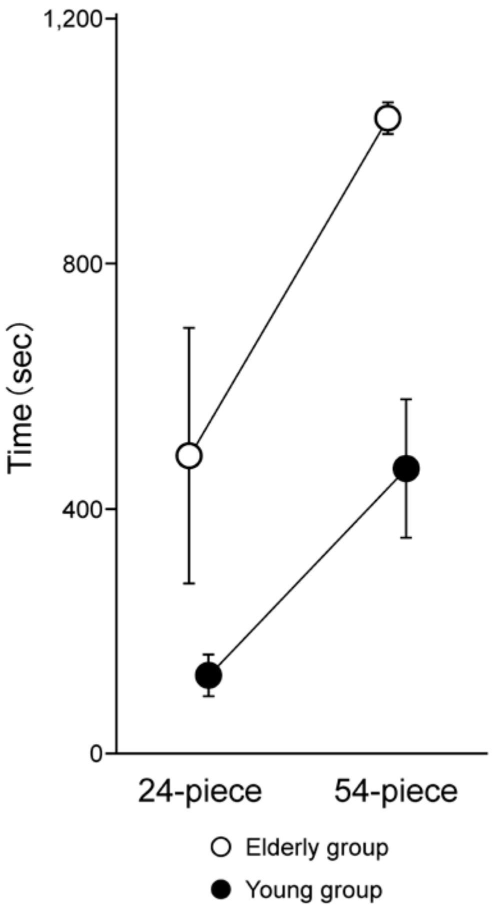

Figure 4. The mean time required for the puzzle tasks. The elderly group required a significantly longer time than the younger group for both tasks ($p<0.01$. ANOVA). Each vertical line indicates a standard deviation.

Figure 5

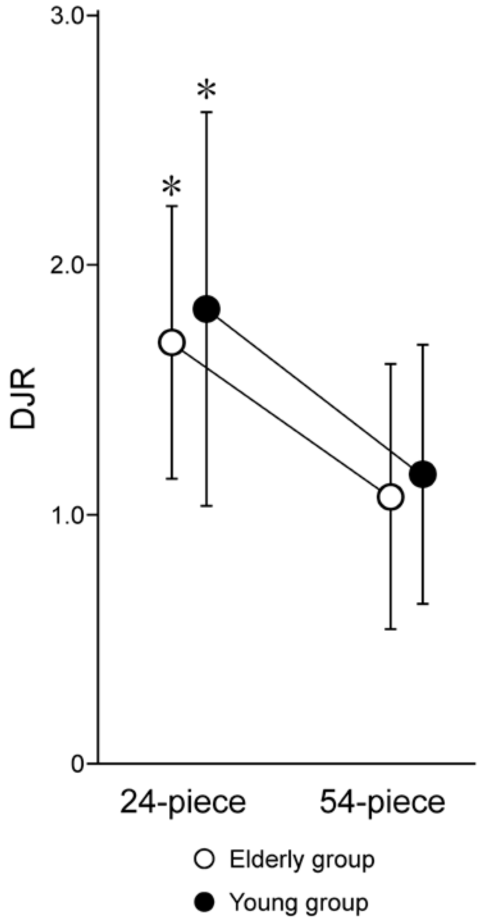

Figure 5. The mean duration judgment ratio (DJR) during the tasks. Both elderly and young subjects estimated a time longer than the actual time during the tasks, i.e., the DJR value was more than 1.0. The effect of the group on the DJR was not significant in each task, while the effect of the task on the DJR was significant ($p < 0.001$, ANOVA). The value was greater in the 24- than 54-piece task in both groups (* $p < 0.01$, Tukey-Kramer's test). Each vertical line indicates a standard deviation.

Figure 6

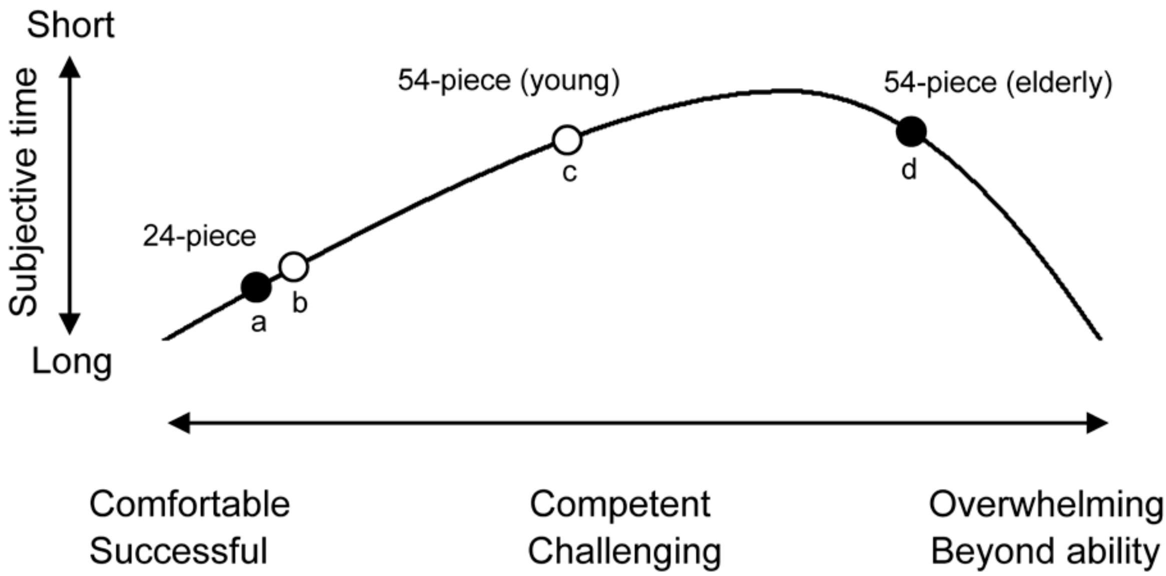

Figure 6. Hypothetical explanation of the results for time estimation in young (open circles) and elderly (solid circles) subjects of the present study (the time estimation curve is a modified figure of Larson (2004, 2010)). Both groups successfully completed the 24-piece task (a and b). For the 54-piece task, young subjects were challenged (c), while it was too difficult for elderly subjects to complete (d), although the outcome of the 54-piece task in elderly was different from those in the other three tasks (see text).